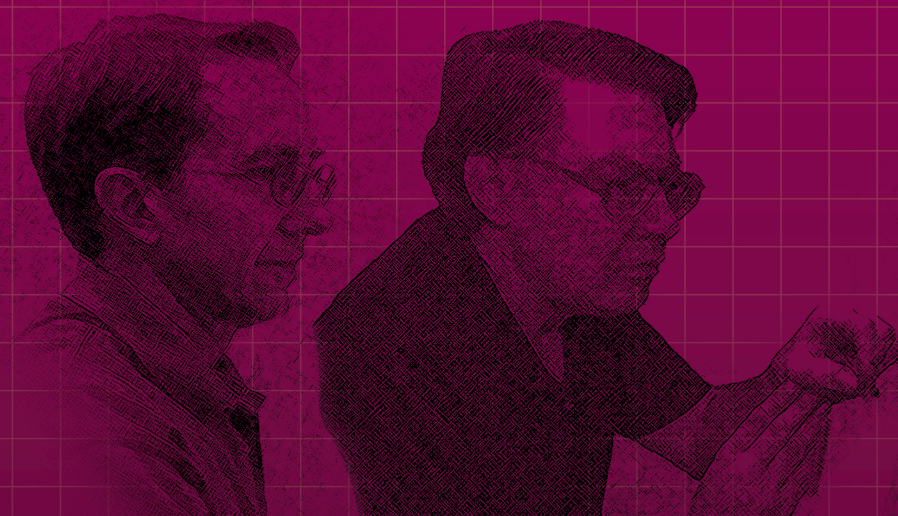
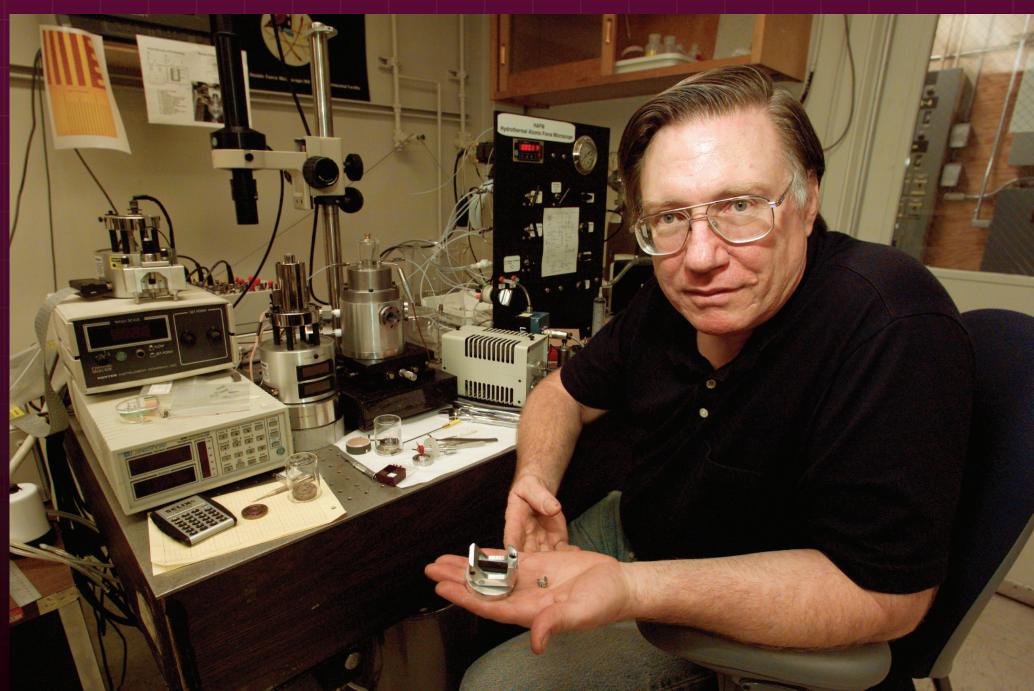


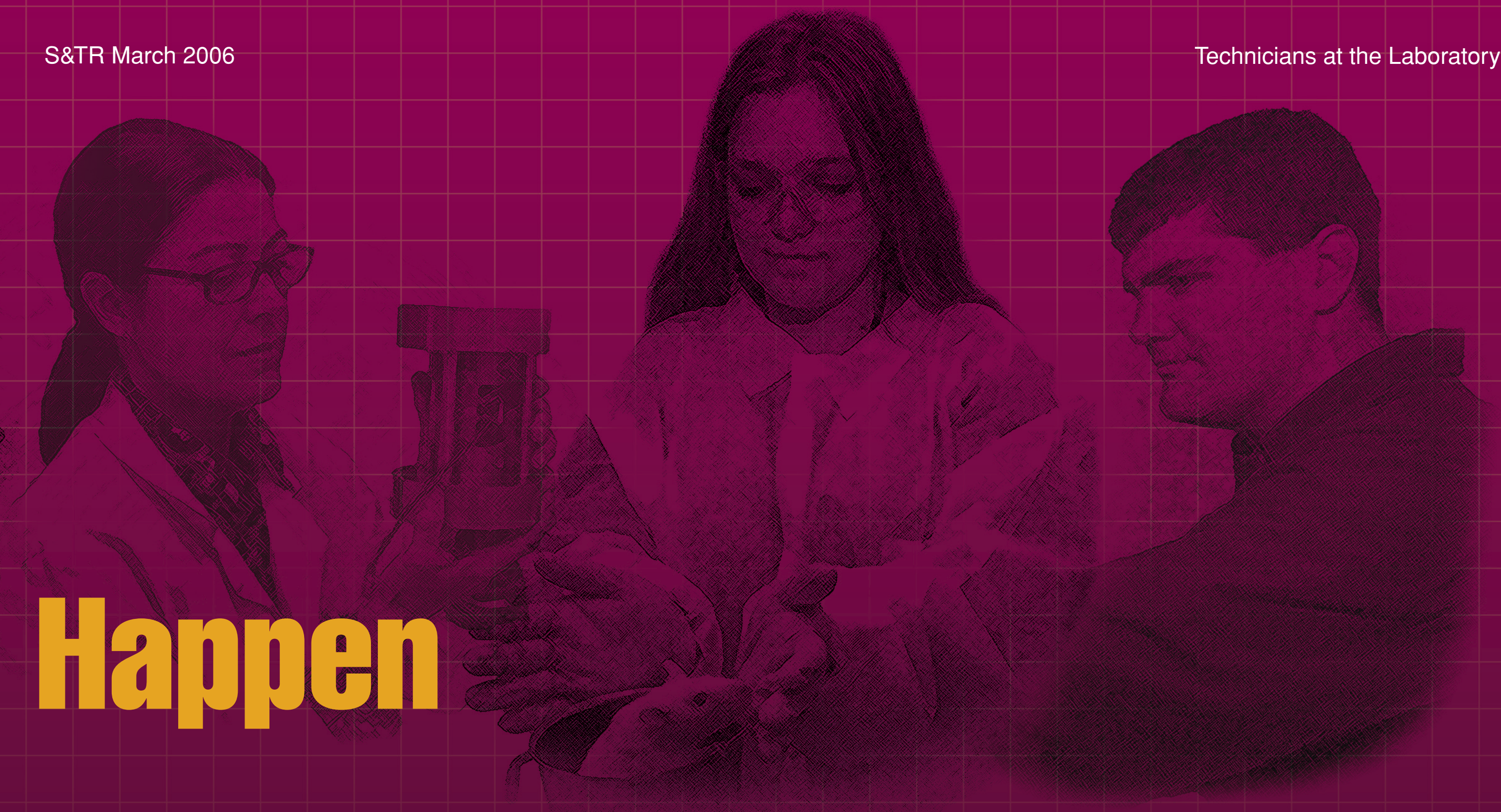
These People Make Things

Rarely in the limelight, technicians at Lawrence Livermore are essential to successful research projects.

ERNEST O. Lawrence, the Laboratory's namesake, pioneered the concept of team science, in which experts from different disciplines combine efforts to tackle challenging problems in science and national security. Most Livermore research projects have people on the team who often work behind the scenes to "make things happen." Known as technicians, technical specialists, scientific associates,



Carl Boro has a reputation for being able to build any kind of part for geophysics experiments.



Happen

and other terms, these men and women comprise more than 20 percent of Lawrence Livermore's workforce of 8,000 employees.

Technicians typically have an associate's or bachelor's degree and work alongside scientists with more advanced degrees. Their work is essential; however, technicians can be overshadowed by principal investigators and lead researchers. Nevertheless, "techs" contribute significantly to technical innovation at Livermore. In their various assignments, they accumulate a wealth of knowledge about how to build a part, run an experiment, design an instrument, or calibrate a device, skills that often come from experience outside formal education.

The important contributions of techs are exemplified by five profiles: a scientific instrument maker, a high-explosives "ramrod," a shot operator for the world's most powerful laser, a bioresearcher of pathogenic bacteria, and a systems administrator for the world's most powerful computer. As their stories show, they have a passion for the Laboratory's mission, and they are part of the outstanding, dedicated teams that, in Director Mike Anastasio's words, are "the key to Livermore's enduring success."

Boro Can Make It

After graduating with a bachelor's degree in industrial studies, Carl Boro considered a job as a high school shop teacher. Instead, he decided to join the Laboratory so he could use his skills in pursuing research done at few other places.

Even after 28 years at the Laboratory, says Boro, "I keep discovering I can stretch my limits." But he cautions that this success comes with a hidden danger. "When you've done the nearly impossible, the next time around, they want you to do the impossible."

Boro is a senior engineer technical associate in the Experimental Geophysics Group within the Energy and Environment Directorate. The group conducts laboratory experiments to measure the physical and chemical properties of materials, mineral and rock physics, chemical transport, and mechanics of rocks and fractures. The group also focuses on laboratory measurements related to underground imaging and material behavior under high pressures using diamond anvil cells and other experimental apparatus.

Boro designs and manufactures one-of-a-kind parts and instruments for these geophysics experiments. According to scientist Brian Bonner, "If we can't buy it, Carl will make it."

"People come to me with an idea for an experiment," says Boro. "I ask them to tell me what they're trying to accomplish."

Bonner says, "I used to come in with a sketch and dimensions for a new instrument. Now, we discuss what the project entails. By the time I'm finished talking with Carl, I've got something different, but better."

Boro has replaced the drafting table, paper, and pencil he once used to draw proposed parts with computer software. Most of his shop tools, however, have remained the same: mills, lathes, a surface grinder with diamond wheels, welding equipment, saws, and micrometers. He occasionally sends work to specialists within the Laboratory, such as laser welders and techs in the water jet shop, or to outside vendors.

Because experiments are always changing, "I do a little of everything," he says. "There's always something new." Boro once built a nonmagnetic instrument for an experiment at the Nevada Test Site. The instrument featured two 7-meter-long booms that rotated around a nonmagnetic turntable. He also designed a device that measures how much seismic energy is absorbed by an earthen material.

For another assignment, he designed and built a device to hold an evacuated, 1-meter-diameter glass sphere as it was lowered from a research ship to a predetermined depth underwater. When the sphere is imploded, it generates an acoustic signal that can be used to calibrate instruments for verifying nuclear treaties.

Boro recently completed tiny parts for the hydrothermal atomic force microscope, which was built at Livermore. It is used to study crack growth in minerals. The microscope, which earned Boro four patents, allows an experimenter for the first time to control pressure and temperature and image samples as they are being bent. The bending jig is less than 10 millimeters in diameter.

"The scientists knew what they wanted to measure but weren't sure how to accomplish it," he says. Boro first built a model five times larger than the final parts so he could more easily determine what was feasible. The machined parts, made of titanium and sapphire, use a tiny set screw to bend the sample. Boro machined a 1.7-millimeter nickle alloy set screw of 127 threads per inch because he couldn't find one to purchase.

Boro's efforts have not gone unnoticed. He was part of the team that won a 2003 Lawrence Livermore Science and Technology Award for experiments on the equation of state of plutonium. He was also on the team that won a 1997 R&D 100 Award from *R&D Magazine* for the oil-field tiltmeter. An array of these instruments is used to monitor oil-well hydrofracturing, a technique for cracking deeply buried rock to provide channels through which oil can flow. (See *S&TR*, October 1997, pp. 4–5.)

Lisa Lauderbach prepares a sample of energetic material for testing in the Laboratory's High Explosives Application Facility.

An Explosive Career

Following her natural bent to understand how things work, Lisa Lauderbach graduated from San Joaquin Delta College with an associate of arts degree in mechanical engineering technology. "At Delta College, I learned there are real jobs for people with skills like mine," she says. Two of her instructors were part-time Livermore employees, and they encouraged her to apply at the Laboratory.

For more than a decade, Lauderbach has worked at the High Explosives Application Facility (HEAF), a center for developing and testing energetic materials. She was recently promoted to another position in which she uses her knowledge of mechanical technology.

Working closely with mechanical engineer Bruce Cunningham and chemist Raul Garza, Lauderbach specializes in two areas of energetic materials research: mechanical properties testing and explosives testing. Together, these tests provide valuable data on an energetic material's mechanical, performance, and safety characteristics.

Mechanical properties tests involve subjecting an explosive to various loads and temperatures to help predict its performance even after long periods of storage. In experiments that can last from seconds to weeks, Lauderbach looks for obvious changes, such as large cracks, and the hard-to-detect, such as 1 micrometer of movement in a long-term "creep test." She also helps design and fabricate parts for testing instruments. For example, one machine she worked on alternates between tensile (pulling) and compressive (squeezing) stresses to investigate a material's response to repeated cyclic loading.

Lauderbach works at a control panel in a laboratory protected by concentric walls of reinforced concrete for safety. From there, she runs mechanical properties tests, analyzes the resulting data, and writes reports to the principal investigators.

On the explosives tests, Lauderbach is known as an experimental "ramrod." In this capacity, she schedules and designs a shot, fields diagnostics, analyzes data, and reports the results. Explosives tests help determine a material's performance and safety characteristics. HEAF is designed to test up to 10 kilograms of TNT-equivalent in specially designed containment vessels. Shots with explosives are typically preceded by one or two dry runs, and tests are conducted by specialized technicians.

Explosives tests use several diagnostics, including high-speed optics and timing pins. The multibeam Fabry–Perot velocimeter, a diagnostic designed by Livermore scientists, provides high-resolution continuous velocity data about materials traveling up to 3,000 meters per second. Most of these experiments are part of research for the National Nuclear Security Administration's (NNSA's) Stockpile Stewardship Program, but Lauderbach has also conducted tests on explosive materials for the Federal Bureau of Investigation and the Department of Homeland Security. "Conducting explosives experiments is challenging work," she says.

Lauderbach started at Livermore in the Engineering Directorate as a mechanical technician assigned to Site 300, the Laboratory's research facility for large-scale high-explosives (HE) processing and testing. She supported HE operations by designing, fabricating, and installing mechanical parts and systems, learning from people who had decades of experience working safely around HE. Eventually, she supported hydrodynamics tests, which are used in stockpile stewardship research to measure the hydrodynamic characteristics of metals as they are detonated.

Transferring from Site 300 to Livermore's site, Lauderbach joined the Environmental Protection Department's Radioactive and Hazardous Waste Management Division. She supported nine Livermore facilities, including the Superblock (where special nuclear materials are stored), Biosciences Directorate, and HEAF. Because of her experience working with energetic materials and hazardous waste, she became the lead environment, safety, and health specialist for HEAF. In this position, she manages the containment and disposal of energetic materials waste for Livermore's main site.

Lauderbach has returned to Delta College to share with students her experiences at Livermore. She appreciates the opportunity to give back to the college and discuss her career because, she says, "People at the Laboratory have been extremely generous with their knowledge."

As lead operator for the National Ignition Facility, Rod Saunders is expert in orchestrating a laser shot.

On the Laser's Edge

When Rod Saunders arrived at the Laboratory with an associate of arts degree in electronics, he looked forward to a career in the same field. "I thought my job would be all electronics." Instead, Saunders was quickly recruited to join Livermore's laser effort to build increasingly powerful lasers composed of thousands of optical components. "A series of doors opened up for me," he says, "many of them unexpected."

Some 34 years later, Saunders is lead operator for the National Ignition Facility (NIF), the most powerful laser in the world. He also has become one of the

they combine advanced instrumentation with the latest understanding of the structure and function of cells and viruses. Jennifer Montgomery joined this effort 4 years ago after graduating with an associate of arts degree in natural sciences from San Joaquin Delta College.

Montgomery had planned to go to nursing school and took courses in biology, microbiology, and physiology. However, her husband's parents both worked at Livermore and suggested she apply. "I was hired in part because of my experience with animals," she says. Indeed, growing up in California's Central Valley, she raised sheep, pigs, steers, and heifers as a member of Future Farmers of America.

Montgomery joined a Livermore team studying the effects of complementary and alternative medicines, an effort supported by the University of California Breast Cancer Research Program. Many cancer patients and survivors self-administer complementary and alternative medicines in an effort to augment conventional treatments, improve health, or prevent recurrence. Herbal tonics often become popular with breast-cancer patients because anecdotal evidence indicates the tonics can treat or prevent the disease. "The herbs used to make the tonics that we studied are important in Asian medicine," says Montgomery, "but little information was available about their safety, efficacy, and potential reactions with prescription drugs."

In this project, Montgomery studied laboratory rats that had been exposed to the carcinogen dimethyl benzanthracene (DMBA) to induce mammary tumors. She administered a tonic containing eight herbs orally to one group of rats. A control group was not fed the tonic. After 23 weeks, the animals were euthanized, and their mammary tissues analyzed. Counter to expectations, the results showed that ingesting the tonics promoted the growth of existing tumors and induced the formation of new tumors, compared with tumor growth in the control group.

Montgomery also studied the effects of the herbal tonic on human breast-cancer cells. This research indicated that the tonic activates estrogen receptors, thereby increasing proliferation of breast-cancer cells. Montgomery presented a poster on the group's findings at a conference of the American Association for Cancer Research.

She notes that many state and federal regulations address the treatment of animals used in medical research. In addition, Livermore's Animal Care and Use Committee oversees Laboratory research involving animals. Montgomery credits people in Livermore's Animal Care Facility for teaching her how to humanely handle mice and rats.

Montgomery recently joined the Biodefense Proteomics Group, part of Biosciences' Defense Biology Division. The group supports homeland security and biodefense preparedness by characterizing interactions between a host and pathogens. Her work is part of a greater effort at Livermore to detect, identify, image, and understand pathogens.

The Biosciences group is investigating such pathogens as *Yersinia pestis* and *Bacillus anthracis*, the agents of plague and anthrax, respectively. These agents are of considerable concern to human health from a civilian biodefense perspective. Montgomery's focus is on discovering what proteins are manufactured by *Y. pestis* and determining other biochemical changes that are triggered by the bacterium. In this way, bioscientists may be able to develop a rapid test that would indicate the presence of *Y. pestis* in the body before telltale symptoms occur—and people become infectious.

The group uses mammalian cells and whole human blood to explore host–pathogen interactions. Researchers use two-dimensional gels, chip-based mass spectrometry, and protein arrays for identifying the markers or signatures of pathogen presence.

"I've learned almost everything on the job," Montgomery says, crediting people in Biosciences for making her a full-fledged member of their research effort.

From Games to Physics

It seems fitting that the person overseeing the care and maintenance of the world's most powerful supercomputer wrote his first C program in junior high school. "I've always been into computers," says Adam Bertsch, who studied electronics in high school and left college midway through his studies to work for Sprint, VA Linux Systems, and then Sony Computer Entertainment Corporation in Silicon Valley.

At Sony, Bertsch was systems administrator for a group that created software tools used by developers of the forthcoming Sony PlayStation®3. While there, he heard about job opportunities at Livermore from people he met at California State University at Chico. "I was interested in being on the cutting edge of technology, doing new and exciting stuff," says Bertsch. "I knew that the world's fastest computers come through Livermore, and I'd always have new challenges here."

Bertsch joined the Computation Directorate in 2004, working on the desktop support team. He soon transferred to the Production Linux Group, which he describes as a "young, hip group." As a systems and network associate, he is one of eight systems administrators who support more than 20 high-performance computing systems. These supercomputers, which are part of NNSA's Advanced Simulation and Computing Program, perform enormous calculations to simulate the physics of nuclear weapons for researchers in Livermore's Defense and Nuclear Technologies (DNT) Directorate.

Bertsch is the primary systems administrator for BlueGene/L, the world's most powerful supercomputer. One part of his job is "fighting fires" on the machine. Some problems are transient and do not require action, but others are linked to an occasional hardware failure.

BlueGene/L has 65,536 nodes, each with 2 microprocessors and its own file system of 224 servers providing 1 petabyte of disk space. Inevitably, microprocessors, compute cards (containing 2 nodes), and disk drives fail and must be replaced. (See *S&TR*, April 2005, pp. 23–25.)

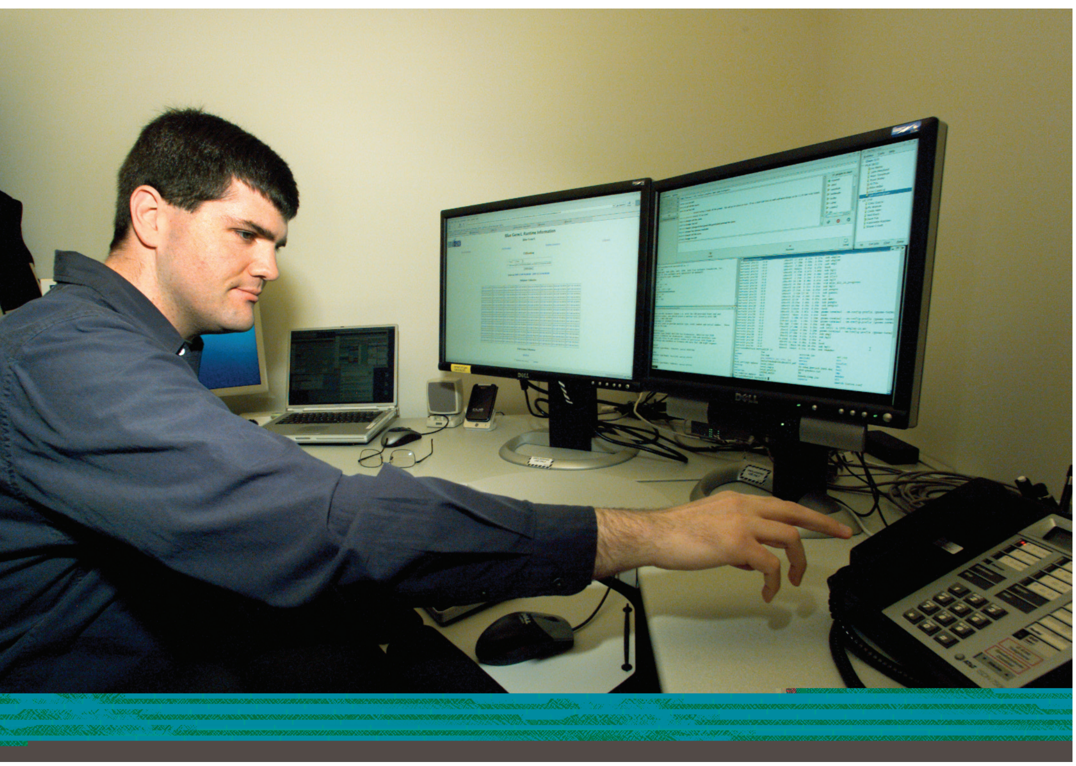
While the machine undergoes a long checkout process before being turned over to DNT for classified use, it is available to a few users for unclassified simulations. These early science runs have resulted in important research results. "We've been conducting science on this machine with exciting results," he says.

In 2005, the machine demonstrated its potential when it ran molecular dynamics simulations of tantalum under high pressure. First 16 million atoms were simulated and then 500 million atoms. When Livermore's Multiprogrammatic Capability Resource supercomputer was used to simulate 64,000 atoms, those calculations showed a solid–liquid border that seemed to be ordered. In the higher-resolution simulation on BlueGene/L, however, the boundary appeared to be chaotic.

As systems administrator, Bertsch schedules machine downtimes for maintenance, helps users through the Livermore Computing phone hotline, and writes documentation that describes fixes to problems so other technicians will know what to do should the problem recur. "We do work no one has tried before," says Bertsch. "Most systems administrators can find solutions to problems by using an Internet search engine because someone out there has almost certainly solved the exact problem before. But no one has ever done the things we're doing at Livermore."

Bertsch is also working with IBM and Livermore experts on planning for two generations of supercomputers beyond BlueGene/L. He has traveled to IBM research and manufacturing facilities in Rochester, Minnesota, and is helping to document requirements for these next-generation systems.

In comparing his experience at Livermore with that of private industry, he says, "The Laboratory's academic environment allows us to focus on what is possible instead of what is profitable." Bertsch is completing his lower division requirements at Los Positas Community College. He plans to use the Laboratory's option to earn a bachelor's degree in computer science from California State University at Chico through video and online instruction. "A huge part of why I came to the Laboratory is that people are so supportive of education," he says.



Adam Bertsch is the primary systems administrator for BlueGene/L, the world's most powerful supercomputer.

Looking Ahead

Demand continues to grow for technicians with a broad variety of backgrounds. Technicians with special skills, aptitudes, interests, and experience are essential to the Laboratory's success. Without them, team science would be missing some crucial players.

—*Arnie Heller*

Key Words: Advanced Simulation and Computing Program, biodefense, BlueGene/L, complementary medicine, High Explosives Application Facility (HEAF), Multiprogrammatic Capability Resource supercomputer, National Ignition Facility, proteomics, University of California Breast Cancer Research Program, *Yersinia pestis.*

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